CHANGE DETECTION ANALYSIS OF TALCHER COALFIELD USING REMOTE SENSING AND GIS

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY

By

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DEPARTMENT OF MINING ENGINEERING

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CERTIFICATE

This is to certify that the thesis entitled **"Change detection analysis of Talcher coalfield using Remote Sensing and GIS"** submitted by **Sourav Choudhury** in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma**.**

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ABSTRACT

The present study focuses on the use of Remote Sensing and GIS as a tool for change detection and land use analysis at Talcher region, Odisha. The region is well known for huge coal mining. Talcher coalfield is one of the major coal producers of the country, and contributes nearly 16.3% of the country's total reserve. The land cover changes in Talcher area was analyzed for the three different years – 1973, 1990 and 2009. The LANDSAT MSS imagery for 1973 and LANDSAT TM imagery for the years 1990 and 2009 were used for the study. Along with land use and land cover maps, NDVI maps of the area for the given time period have been created. The results show a tremendous increase in the mines area and settlements. Though the water body has not suffered much change but the forest area has drastically decreased.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO THE STUDY:

The change in land cover as a result of anthropogenic activities has played a major role in global environmental change and hence has become a hot spot for researchers (Liu et al., 2002). It is the process of identifying variations in an object or phenomenon by observing it at different times (Singh, 1989). The alteration in land cover including tropical deforestation has attracted worldwide attention because of its potential effects on soil erosion, run-off and carbon dioxide level (Joshi et al., 2006). Change detection compares the differences in spectral signatures from images taken of the same area in different time periods (Don, 2011). The detailed process involves superimposing maps of more than one time period over each other to find the change (Jessica et al., 2001).

In the present study 3 different satellite images of Talcher coalfields belonging to 1973, 1990 and 2009 is used to carry out change detection analysis. The land use and land cover maps for all the three time periods is created taking into account the various major components that have been affected by the mining activities at Talcher.

1.2 USE OF REMOTE SENSING IN CHANGE DETECTION:

Remote sensing refers to the science and art of obtaining useful information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation (Lillesand et al., 1979). It can also be defined as the science of acquiring processing and interpreting images that record the interaction between electromagnetic energy and matter (Sabins, 1997).

Before the use of satellite imagery and computers land use and land cover maps were prepared using tracing paper over topographic sheets. Land measurements and surveys were carried out using measuring tapes, graph sheets, ropes and drawing boards. These methods were not only tiresome and labor intensive but were also flawed due to human errors.

Later aerial photographs were used for the land cover and land use pattern study. But they also had there disadvantages like identification of ground features were difficult without landmarks, location and scale were approximate. They were black and white; hence distinguishing features from one another was difficult.

But now a days with availability of satellite imagery, that are multispectral (that acquire image data at specific frequencies across the electromagnetic spectrum), multi-temporal (images that have been taken over a period of time) and have very high spatial resolution, change detection studies of inaccessible places have also become much more accurate, efficient and can be frequently carried out.

1.3 STUDY AREA:

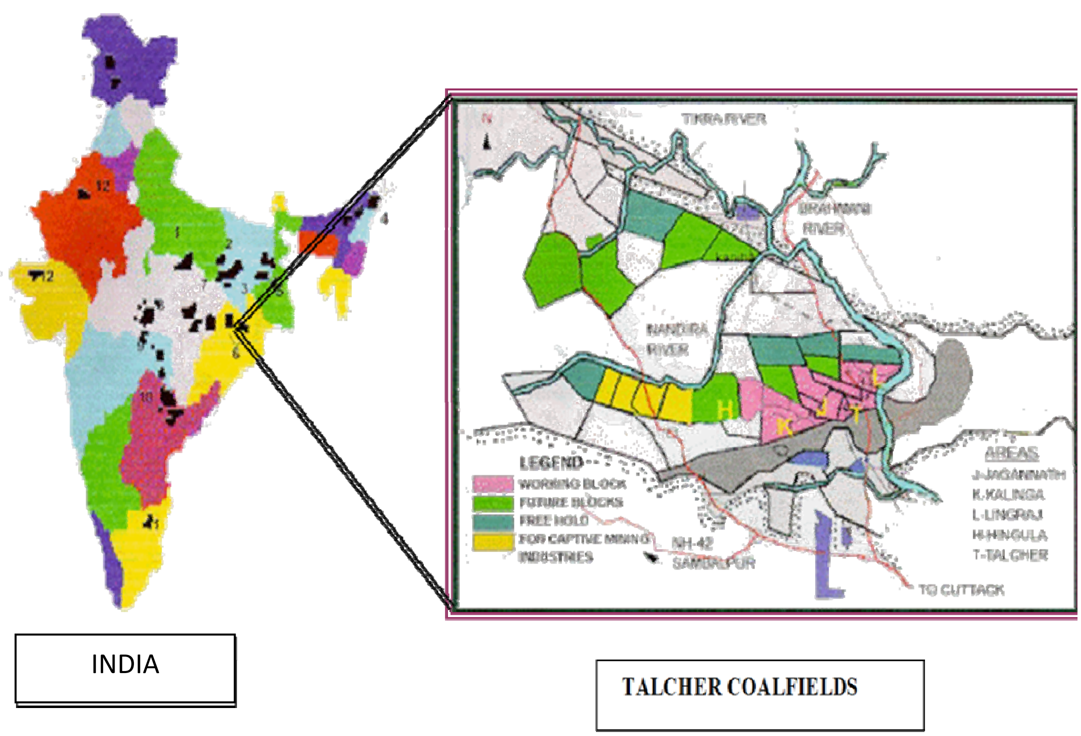

Figure 1.1 Location of Talcher coalfield

Talcher coalfield is situated in the eastern part of Odisha as shown in Figure 1.1. It is about 110 km long and 25 to 35 km wide covering an area of about 1860 km^2, with a potential of 1580 km^2, bounded by latitudes 20°53' 00" N to 21°12'00" N and longitude 84°20'00" E to 85°23'00" E. Talcher basin occurs as a detached elliptical basin surrounded by igneous and metamorphic rocks of Precambian age and represents the south eastern most member of lower Gondawana basins within Mahanadi valley garben. It is located at the tectonic junction of granite–greenstone rocks of Sighbhum Craton to the north and high-grade granulite facies rocks of Eastern Ghat to the south. This basin hosts a thick lithic fill of Gondwana sediments consisting five lithostratigraphic units, viz. Talchir, Karharbari, Barakar, Barren Measures and Kamthi Formations (Jayakumar, 2011).

Coal was discovered in Talcher at Gopalprashad in 1837. Handidhua Colliery was opened by M/s Villers in 1921. The total geological Reserve of Talcher coalfield is estimated to be about 44.64 billion ton as on 01.04.2011(CMPDI, 2011), which contributes to nearly 16.3% of the country's total reserve. The total production of Talcher coalfield was about 53.67 million tons in 2007-08. At present there are 5 operating areas in Talcher coalfields including 7 open cast mines and 3 underground mines in operation with manpower of 10,220.

The 5 operating areas are:

1. Jagannath Area
2. Bharatpur Area
3. Hingula Area
4. Lingaraj Area
5. Kaniha Area
6. Talcher Area

The names of the different Open Cast Projects (OCP) are:-

1. Balanda OCP
2. Jagannath OCP
3. Annanta OCP
4. Kalinga OCP
5. Bharatpur OCP

6. Hingula OCP
7. Lingaraj OCP

The names of the different underground mines in Talcher are

1. Deulabeda Colliery
2. Talcher Colliery
3. Nandira Colliery

The pit head consumers of Talcher coalfields are Talcher Thermal Power Station (NTPC), NTPC Kaniha, National Aluminum Company Limited, private washeries like Global Coal Washeries and other private companies like APGENCO, Vishakhapatnam Steel, KPCL, RPTT etc.

1.4 OBJECTIVE:

The objectives of the study include:

- To create land use and land cover maps of Talcher area for the years of 1973, 1990 and 2009.
- To generate Normalized Difference Vegetation Index (NDVI) maps of the area for the particular time period.
- To carry out change detection analysis.

CHAPTER 2
LITERATURE REVIEW

2.1 LITERATURE REVIEW

Change detection analysis is a versatile tool that can be used in mapping the differences land cover pattern in many fields like urban area, forests, river, lakes and mining. Along with calculating change area of each land feature NDVI values can also be used to give a clearer picture of the changing scenario. Normalized Difference Vegetation Index [NDVl= (Infrared - Red)/ (Infrared + Red)] is a band ratio (Rouse et al., 1973) that gives higher values for vegetation parameters and lower for water bodies. Therefore, it can be used for vegetation discrimination.

Joshi et al (2006) used the Landsat MSS, TM, ETM and IRS P6 LISS III digital data of the Korba coal mines the years 1972, 1990, 1999 and 2004 to evaluate the changes in land use pattern. The analysis included the following classes (I) Forest (not impacted, highly degraded, medium degraded, less degraded), (2) Non-forest (not impacted, highly degraded, medium degraded), (3) Active Mines, and (4) Water Body. NDVI values were calculated to depict dense vegetation, fragmented patched vegetation and mine area. The study showed that there was massive decrease in forest cover and the NDVI values of the reclaimed areas were found to lower than that of initial plant cover.

Anil et al (2010) carried out a study that discusses the land use land cover change due to open cast coal mines in parts of Wardha valley of Ballarpur region, Chandrapur area using Remote Sensing and GIS techniques with IRS-P5, LANDSAT -5 TM images of the area for the years 1990, 2009 and 2010. The results showed that almost all dense vegetation have been converted into mine land and overburden dump which causes pollution level to increase enormously in the surrounding area; recently it has attained the critical level.

In a study by Martha et al (2010) regarding recent coal-fire and land-use status of Jharia Coalfield, the thermal band in Landsat-7 (ETM) 2003 and ASTER data 2006 are used to demarcate the coal-fire areas and various land use features. The study showed that the eastern part of the Jharia Coalfield is more affected by coal fires than the western part.

Singh et al (1997) studied the impact of coal mining and thermal power industry on land use pattern in and around Singrauli coalfields using Remote Sensing data and GIS by using LANDSAT MSS and TM images of the years 1975, 1986 and 1991. The results made it clear that there was increase in mining area and substantial loss in agricultural and forest cover due to rapid industrialization of the area.

Almeida-filho et al (2000) in a study used JERS-1 SAR microwave images of the years 1993, 1994 and 1996 to assess the areas disturbed by gold mining activities in the region of Serra Tepeque´m, Roraima State, Brazilian Amazon. Normalized Difference Index was used to find out the disturbed regions. Normalized Difference Index images indicated an increase in regions disturbed from 1993 to 1994 but no noticeable change was found in between the years 1994 to 1996 that showed area was disturbed prior to 1994.

CHAPTER 3

METHODOLOGY

3.1 FLOW CHART

The methodologies adopted in the project to reach the results are as shown in the Figure3.1:

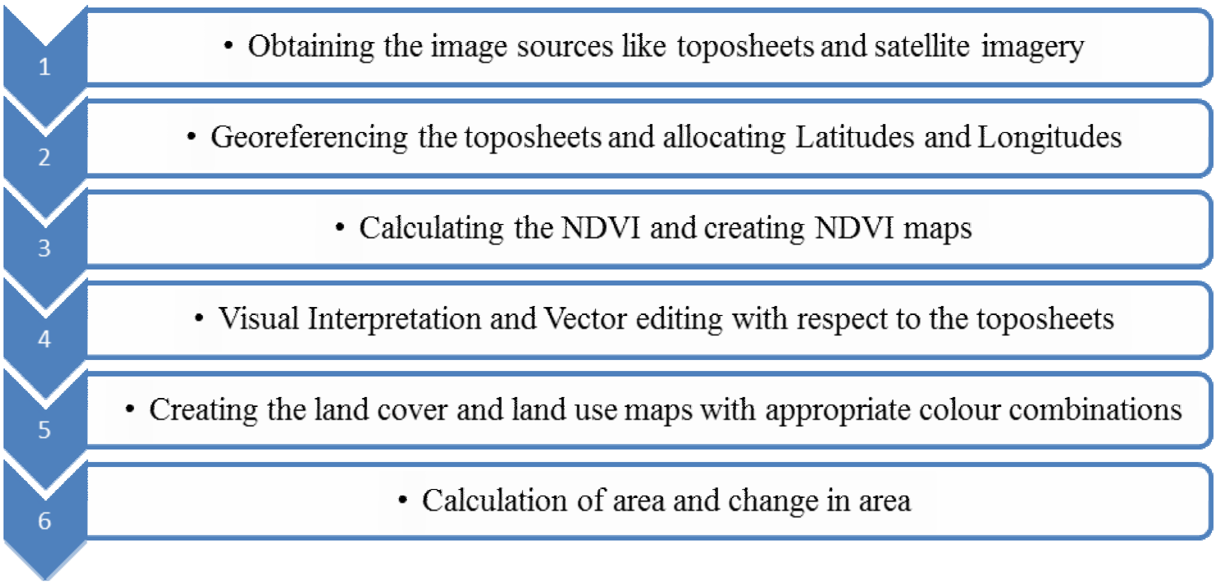

Figure 3.1 Methodology Flow Chart.

3.2 IMAGE ACQUISITION AND SOURCE:

For carrying out the study satellite images of Talcher coalfields were obtained for the three years namely, 1973, 1990 and 2009. For keeping all atmospheric criteria same all the images chosen are of the same month that is November. Details are as shown in Table 3.1.

The image of the year 1973 was obtained from the Global Land Cover Facility (GLCF), a NASA-funded member of the Earth Science Information Partnership at the University of Maryland. The images of 1990 and 2009 were obtained from the USGS Global Visualization Viewer (GloVis) that is a quick and easy online search and order tool for selected satellite and aerial data within the United States Geological Survey (USGS) inventory for the specified location. USGS is America’s largest water, earth, and biological science and civilian mapping agency, the U.S. Geological Survey (USGS) collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems.

The 1975 image is a Multispectral Scanner (MSS) image having resolution of 79 meters. It was obtained under GLS 1975, by Landsat 1-3 Multispectral Scanner (MSS) which collected images from 1972- 1983. The 1990 image is a Thematic Mapper (TM) image having a resolution of 30 meters. It was obtained under GLS 1990 by Landsat 4-5 TM which collected images from 1984-1997. The 2009 image is a Thematic Mapper (TM) image having a resolution of 30 meters. It was obtained under GLS 2010 by Landsat 5 TM and Landsat 7 ETM+ (Enhanced Thematic Mapper Plus) which were collected from 2008-2011.

The study area is covered by four toposheets - 73H/1, 73G/4, 73D/13 and 73H/5. Topohseets of the year 1980 and 2010 were used, and collected from Survey of India, Bhubaneswar.

Table 3.1 Image source

Sl no.	Data type	Production date	Scale	Source
1	Landsat MSS	18/11/1973	79 m	Global Land Cover Facility (GLCF) www.glcf.umiacs.umd.edu
2	Landsat TM	28/11/1990	30 m	USGS Global Visualization Viewer http://glovis.usgs.gov
3	Landsat TM	01/11/2009	30 m	USGS Global Visualization Viewer http://glovis.usgs.gov
4	Toposheets (73H/1,73G/4,73D/13,73H/5)	1980	1:50,000	Survey of India- 1980
5	Toposheets (73H/1,73G/4,73D/13,73H/5)	2010	1:50,000	Survey of India- 2010

3.3 GEOREFERENCING THE IMAGES:

All the satellite images obtained were already georeferenced so only the toposheets were georeferenced. The four corner points of the toposheets were taken as the Ground Control Points as there latitudes and longitudes were already known.

3.4 NDVI CALCULATION AND NDVI MAPS:

NDVI or Normalized Differential Vegetation Index was calculated for all the three images and subsequent NDVI maps were created with NDVI values ranging from -1 to +1.the NDVI calculation for different sensors are as shown in Table 3.2.

Table 3.2 NDVI calculation

Sl no.	Image name	Image type	NDVI function	NDVI range
1	1973 Talcher	Landsat MSS	(band 4- band 2)/(band 4+ band 2)	-1.0 - 0.6
2	1990 Talcher	Landsat TM	(band 4- band 3)/(band 4+ band 3)	-0.6 - 0.6
3	2009 Talcher	Landsat TM	(band 4- band 3)/(band 4+ band 3)	-0.5 - 0.6

3.5 CLASSIFICATION AND VISUAL INTERPRETATION:

Classification by visual interpretation was carried using vector editing. Following classification scheme was chosen as these underwent significant changes due to mining in Talcher coalfields as shown in Table 3.3. The non-forest area includes agricultural land, human settlement, open scrubs, etc.

Table 3.3 Classification scheme

Sl. no.	Class
1	Dense forest
2	Settlements
3	Mines
4	Water body
5	Non-forest area

3.6. CREATION OF LAND USE AND LAND COVER MAP:

Land cover and land use maps of Talcher coalfields for all the three years were created using the above classification scheme by using the following steps:

I. Demarcation of all the areas belonging to each class.
II. Allocating suitable colors to each class.
III. Calculating areas of each class.

3.7 LIMITATIONS:

The LANDSAT MSS imagery of the year 1973 has a poor resolution of 79 m in comparison to the LANDSAT TM images of the years 1990 and 2009 which have a resolution of 30 m. Hence the accuracy of this particular year is low in comparison to the other years. The study is just a preliminary study involving Level 1 classes. For higher order classification a more detailed number of classes are required.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 RESULTS AND DISCUSSION

The results as shown in Table 4.1 make it very clear that there has been a tremendous increase in the mines area from 1973 to 2009 of about 34km^2 which has led to a drastic increase in settlements and a steep drop in the total forest cover. The forest cover has suffered a loss of about 43km^2 because of large scale deforestation caused due to mining activities and construction of settlements. The increase in mines area and industrialization of the nearby areas is the main reason for increase in the settlement area by 28 km^2 in-between 1973 and 2009. The non-forest and water body has not seen much change over the years as can be seen from the graph in Figure 4.1.

Table 4.1 Area occupied by each class year wise

YEARS	1973	1990	2009
FOREST AREA	167.41	146.48	124.11
MINES AREA	2.6	11.23	36.46
SETTLEMENTS	11.38	21.1	39.51
WATER BODY	22.84	21.17	20.83
NON-FOREST AREA	232.3	236.54	215.61
TOTAL	436.53	436.53	436.53

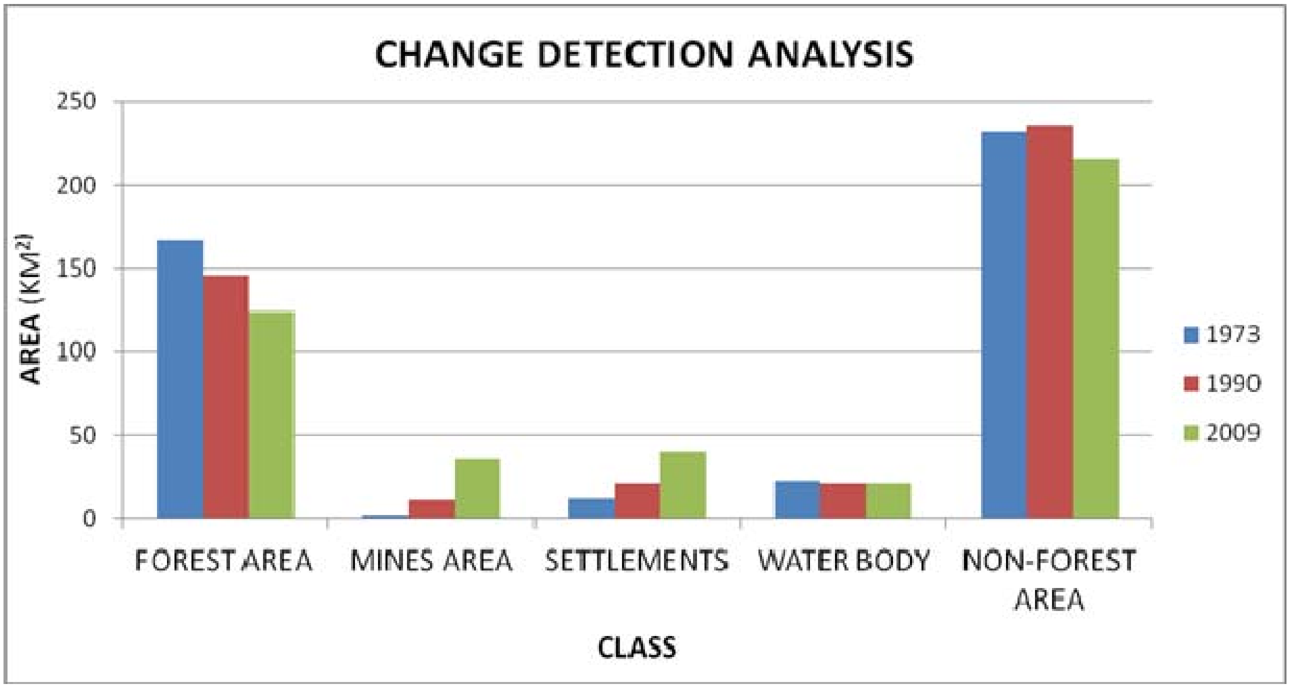

Figure 4.1 Graph showing change in area.

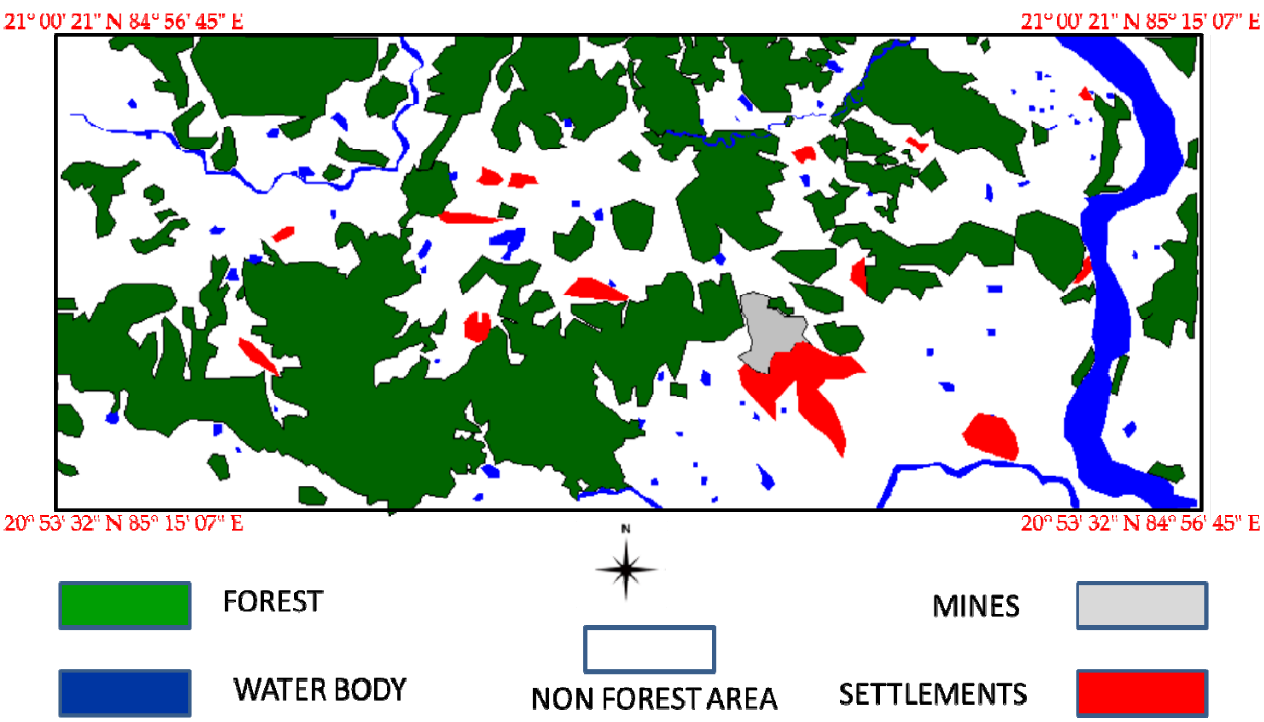

Figure 4.2 Land use map of the year 1973

As it can be clearly seen in Figure 4.2, in 1973 the area was mostly covered with forest which spread over nearly 167.41 km^2. Area occupied by the mines very low and amounted only to 2.6 km^2. Similarly the area occupied by human settlements also was very low as the mines had not started with full flow. The total settlement area was only 11.38 km^2. The area has a number of small water bodies and also the river Bramhani flows through the region. The total area occupied by water bodies add up to 22.84km^2.

In the year 1990 the land use pattern had changed as shown in Figure 4.3. The forest cover had depleted to 146.5 km^2. The mining area covered nearly 11.23 km^2 whereas the settlement area had also increased to 21.1 km^2. The water body did not suffer from much change and occupied 21.17 km^2.

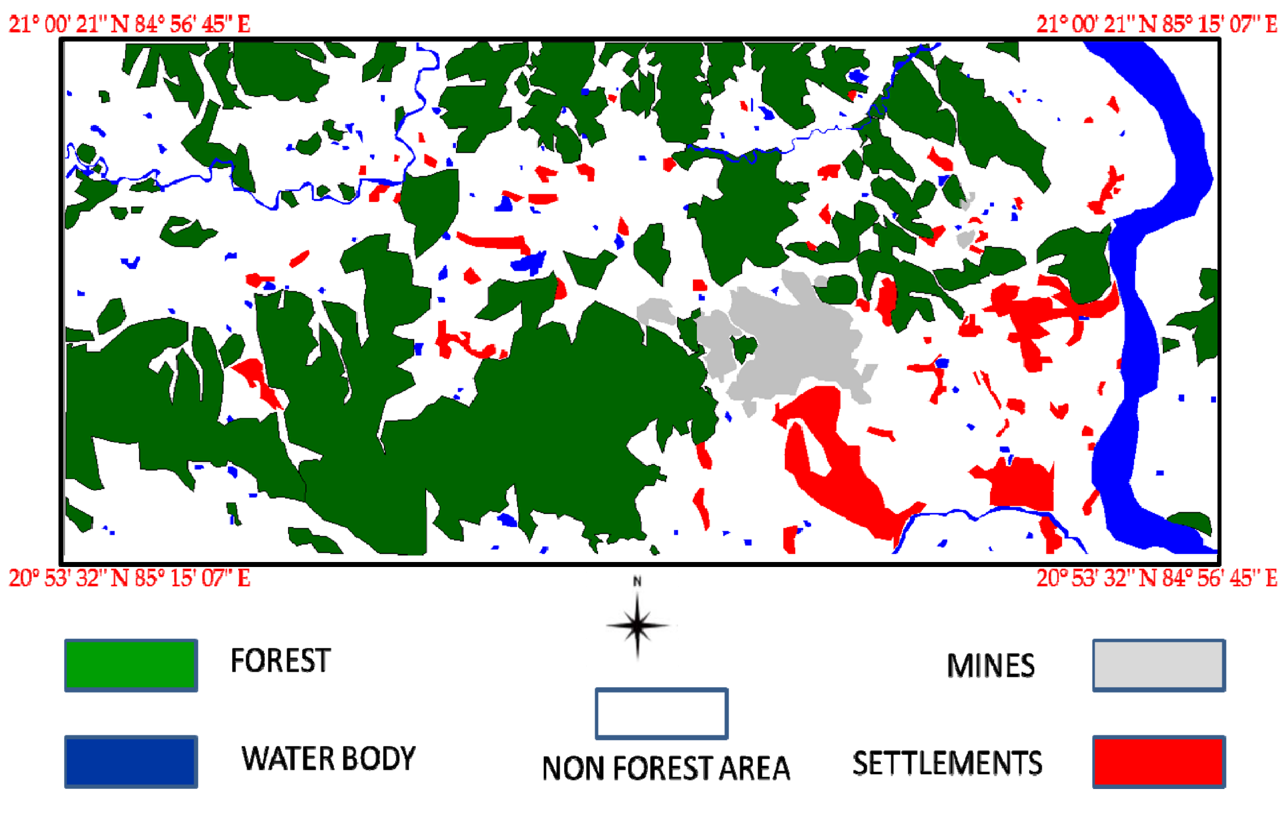

Figure 4.3 Land use map of the year 1990

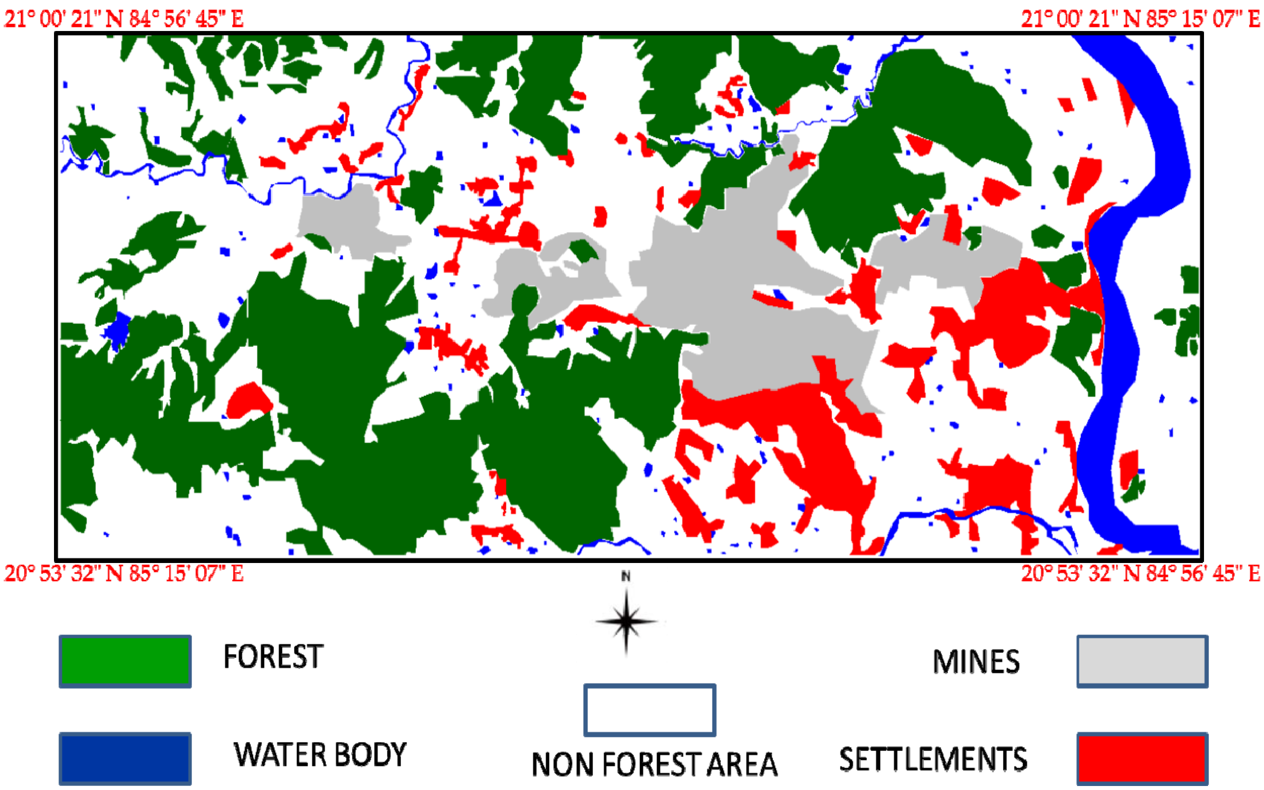

Figure 4.4 Land use map of the year 2009

As it can be seen clearly from the Figure 4.4 the scenario had completely changed in 2009. The mines area tremendously increased to 36.46km^2 . the same increase was also seen in the settlements which occupied nearly 39.51 km^2. The forest area had depleted to 124.11 km^2. The area occupied by the water body did not suffer much change and was still at 20.83km^2.

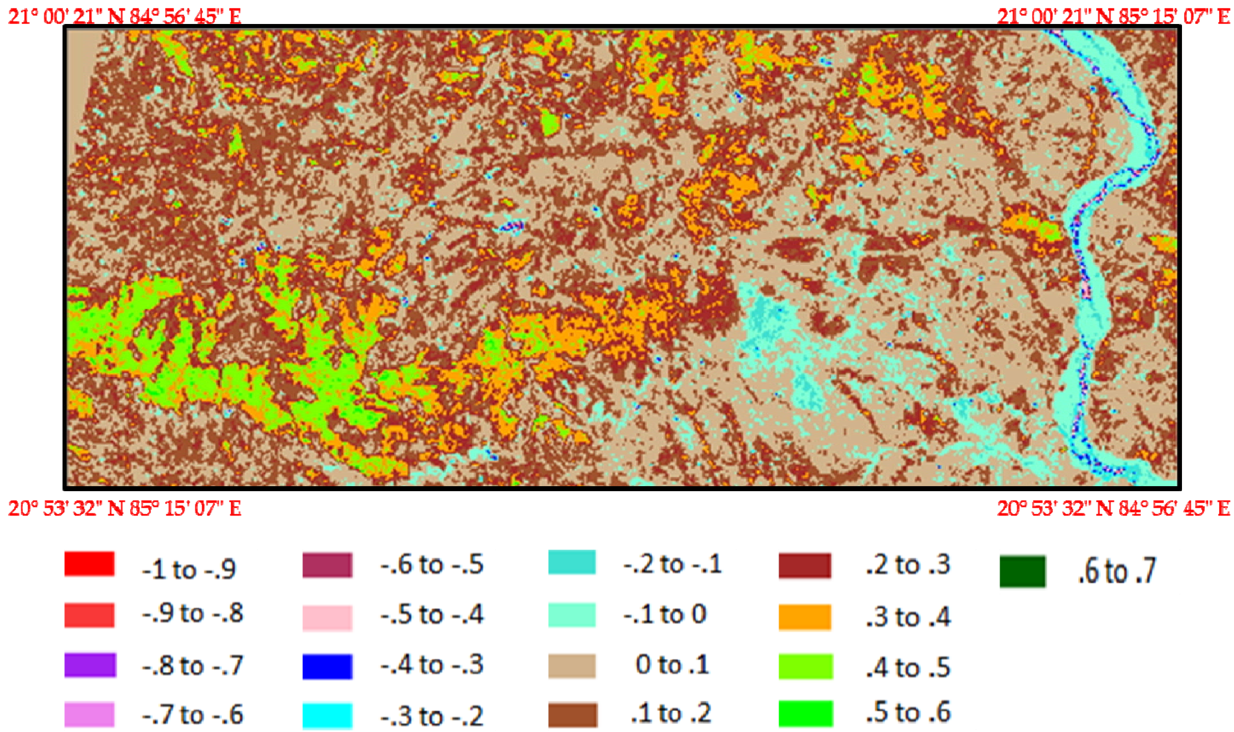

Figure 4.5 NDVI map of the year 1973

The NDVI values for Talcher area varried mostly from -1 to 0.7. As it can be seen clearly the forest area has maximum NDVI values then comes the non forest area follwed by the settlements, mines and finally water body shows the least. From Figure 4.5 it is clear that most area in 1973 was covered by forest. Only a really small area was covered by mines. In the 1990 and 2009 NDVI maps, Figures 4.6 and 4.7 respectively, the gradual decline in the forest area and the increase in mines can be clearly seen. The areas occupied by the mines and settlements has low NDVI values nearer to zero. Table 4.2 shows the variation of NDVI values for different classes in the year 1990. It clearly shows that the forest has the highest NDVI values and water body has the least.

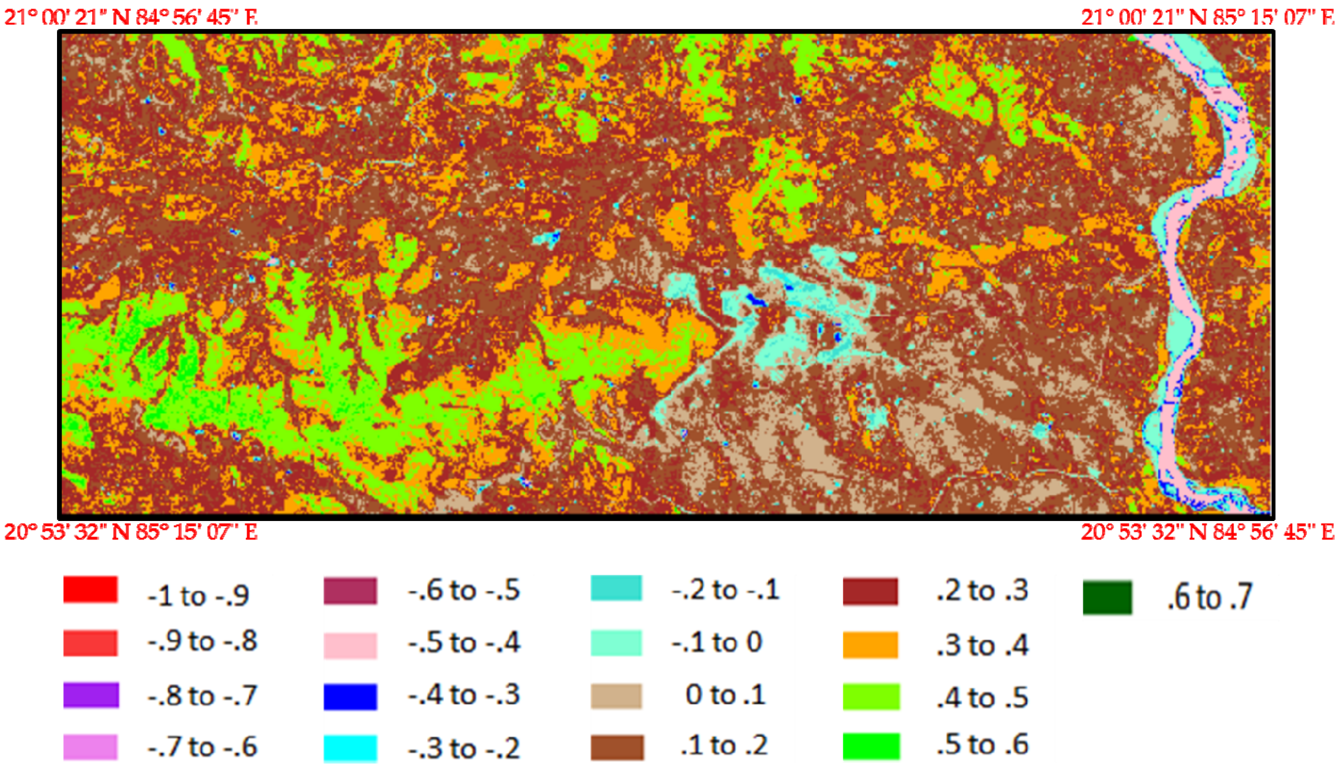

Figure 4.6 NDVI map of the year 1990

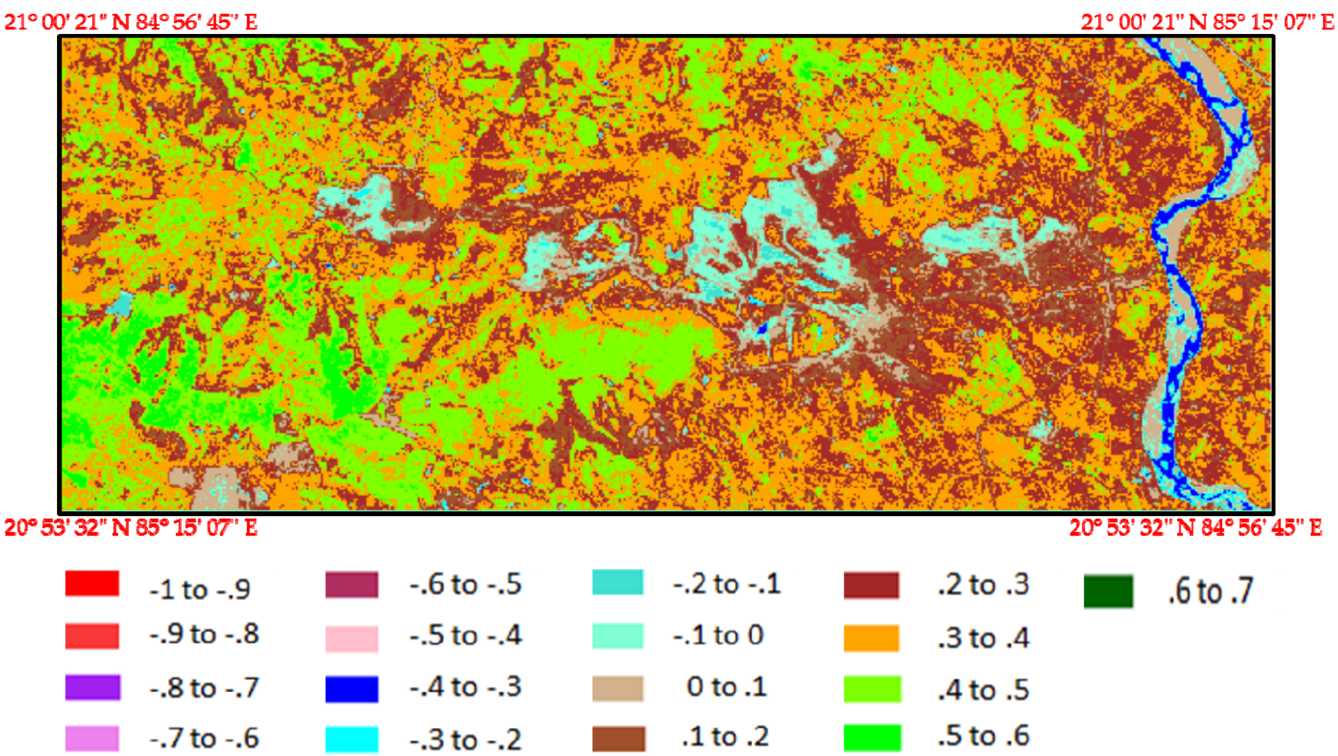

Figure 4.7 NDVI map of the year 2009

Table 4.2 NDVI range of each class for the year 1990

Sl no	class	NDVI
1	Forest	0.38 to 0.58
2	Mines	-0.29 to 0.00
3	Settlements	0.00 to 0.09
4	Water body	-0.53 to -0.40
5	Non-forest	0.10 to 0.29

CHAPTER 5
CONCLUSION

From the study it was found that the total loss in forest cover between 1973 and 2009 is about 43 km^2 and increase in mining area is about 34km^2. Though the water body has decreased but still there is not much difference. The total increase in settlements amounts to 28 km^2. Thus it is clear that large scale mining leads to massive deforestation as can be seen in Talcher area. Hence it is highly essential that use of proper mine closure plan and land reclamation practices must be adapted to bring the area if not fully at least nearer to its original fauna cover. In future use of eco-friendly mining and effective environmental management plan can go a long way in decreasing the adverse effects of mining.

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